National Institute of Standards and Technology

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Better fire fighting through research

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What is the True Cost of Firefighter Injuries?

What is the cost of a firefighter injury on the fire ground? What is the probability of a fire engine accident when responding to an emergency call? These perplexing questions and other related ones are of great interest to NIST researchers as they search for ways to reduce the occurrence and severity of firefighter work-related injuries A new report, prepared by TriData Corporation, ***The Economic Consequences of Firefighter Injuries and Their Prevention***, NIST-GCR-05-874, addresses the cost of these injuries not only to the firefighters themselves, but also to their departments, the insurance industry and society.

The TriData research team conducted the cost-of-injury research by reviewing the existing literature and looking at various models that could be used to calculate the many parts that make up financial losses from injuries.

Other studies were reviewed, as well as injury-related data, and the team then incorporated their original research results, as well as existing research data, into the report.

The estimated cost of addressing firefighter injuries and of efforts to prevent them is $2.8 to $7.8 billion per year. The cost elements that comprised the two studies were based on workers compensation payments and other insured medical expenses, including long-term care, lost productivity, administrative costs of insurance, etc. The Tri-Data team applied a new approach to the analysis and looked at costs that typically have not been factored into firefighter injuries.

Some of the labor costs reviewed were investigating injuries, plus the time required for data collection, report writing, and filing. The study estimated a number of these direct costs including medical payouts, legal fees, and investigations, and these expenses were applied to the total number of injuries.

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Injuries can occur at all fire incidents.

Fire Safety Roundtables - Healthcare Facilities and Nightclubs

The issue of fire safety in healthcare facilities and emerging code issues in nightclubs were addressed at two roundtable conferences hosted by the International Association of Fire Chiefs (IAFC). The project was supported by the Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA).

On April 22, 2004, IAFC invited a cross-section of the healthcare and fire service industry leaders from throughout the United States to participate in the Healthcare Fire and Life Safety Round Table.

The increase in the number of assisted and non-assisted living facilities for retirement living has identified the need for a model life safety plan to be developed and made available to the fire service and to the healthcare and building management communities.

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Cover of the Healthcare Report

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What is the True Cost of Firefighter Injuries?, cont.

Another cost is that which relates to what employers of firefighters pay to provide insurance coverage, and for safety training, physical fitness program, and protective gear and equipment. These expenses relate to injury prevention and reduction of severity of injuries. The study incorporated a number of separate indirect costs including prevention, safety and survival training, physical fitness and wellness programs and applied these expenses to the total number of firefighters, not just the firefighters that were injured. A unique feature of this research project is the workers compensation information that was specific to the occupational codes for firefighters.

The report goes on to identify steps needed to reduce fire-fighter injuries. Information requirements of new safety and loss control initiatives need to be supported. Better data and research on the severity of injuries to firefighters and the associated costs by level of severity are needed. The time it costs to investigate injuries and to document reports, and the amount of lost work because of injuries need to be documented.

A scientific study on the relationship between the number of firefighters per engine and the incidence of injuries would resolve a long-standing question concerning staffing and safety.

If you have additional questions after reading the report, contact Nelson Bryner, nelson.bryner@nist.gov.

Water Runoff After Major Fires Studied

How serious is the issue of water runoff after a major fire? Are environmental impacts increasing, or are people more aware of them? How are the problems being addressed? These are some of the questions that have been raised over time. High impact incidents throughout the world capture the headlines. On November 1986, a chemical warehouse accident at the Sandoz facility in Schweizerhalle, Switzerland (near Basel, Switzerland), captured worldwide attention. Not only were there significant challenges in firefighting tactics, emergency response management and crisis communications with the two nearby countries (France and Germany), there were also the challenges of air and water pollution in a densely populated area.

A paper presented at the 2004 INTERFLAM conference, ***Environmental Concerns of Fires: Facts, Figures, Questions, and New Challenges for the Future***, discusses the environmental impacts of significant national and international fires, including the Sandoz fire. The authors discuss the long- and short-term impact of the fire effluents (runoff) and the environmental effects.

Better understanding of the hazards from emissions and depositions is needed, and also there is a need to develop scientifically sound tools for identification of the hazards, the assessment of risks, and the usage of fire prevention and protection measures. International efforts have been made to address these issues, including the International Standards Organization's Technical Committee 92 on Fire Safety, Subcommittee 3 (ISO/TC92/SC3) that will be addressing not only the local effect of the fire effluent on humans but also its effect on the environment.

To learn more about other major fires, their environmental impacts and worldwide efforts to address these issues, review Dr. Marlair's paper (linked in the second paragraph) or contact him directly, at guy.marlair@ineris.fr.

Smoke plume from a 2002 fertilizer warehouse fire in Murcia, Spain.

Testing Navy Suits with Mannequins

Mannequin entering the burn chamber.

Firefighter protective clothing has improved over the years, but developing realistic and repeatable tests for protective clothing that simulate real-fire conditions is still a challenge for researchers.

Mannequin ready for testing.

Worcester Polytechnic Institute's (WPI) Center for Firesafety Studies has accepted the challenge and is testing next generation firefighter clothing for the U.S. Navy's Clothing and Textile Research Facility in Natick, MA. WPI students have built a fire test simulator, or burn chamber, to recreate a number of fire scenarios—from a blazing living room to a brush fire. The 10 foot by 15 foot (3 m x 5 m) steel-framed chamber sits in the middle of a huge warehouse. A mannequin, hanging from a metal track and manipulated by remote control, can be moved close to or through the flames at speeds ranging from half foot up to two feet per second. Heat flux is measured with 40 specially designed copper slug calorimeters (sensors that simulate the skin's reactions) that are evenly distributed around the mannequin. At the end of a test, students evaluate data from the calorimeters.

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Testing Navy Suits with Mannequins, cont.

Laboratory computers determine whether the mannequin's exposure to heat over time would have produced first, second or third degree burns, or no burns at all. (Skin temperature must equal or exceed 44°C (111°F) to burn.)

Tests show the U.S. Navy's new suit made from highly flame- and heat-resistant Zylon® and aramid apparently works well. The engineers hope to have the gear aboard naval vessels by 2006; it will take up to one or two years beyond this date to reach civilian fire departments.

For more information, go to www.wpi.edu/News/Transformations/2004Winter/investigations.html. or contact Dr. Jonathan Barnett, jonathan.barnett@wpi.edu or Jay Kramarczyk, JFK@RWSullivan.com.

Mannequin Coming out of Burn – Intact.

Fire Safety Roundtables - Healthcare Facilities and Nightclubs, cont.

The purpose of the conference was to identify emerging issues in healthcare facilities (retirement communities, assisted living facilities, nursing homes), begin a discussion, and develop recommendations to improve resident safety. The report, ***Healthcare Fire Safety Roundtable Report, Washington, DC***, summarizes the recommendations and strongly encourages the IAFC to devote staff and resources to ensure that the report's recommendations are carried out. Of interest are two national plans that were suggested: 1) Develop a national plan to address evacuations and a Defend-in-Place concept for healthcare/long term care facilities; and 2) Implement a national plan to transition from unannounced to announced fire drills for healthcare/long term care facilities.

Recent catastrophic fires in public assembly occupancies that resulted in large life loss identified the need to develop strategies for enacting building code changes emphasizing life safety and fire threat reduction in nightclubs and other places of public assembly. As a result, the IAFC held two Emerging Codes Issues Roundtables; one in Bellevue, Washington, on May 6-7 and the other in Nashville, Tennessee, May 27-28. Invited participants represented diverse interests from the code industry and the fire service communities. The types of occupancies discussed were: nightclubs and restaurants; places of worship and school auditoriums; arenas, stadiums, and theaters. Among the conclusions, two are of special interest. First, the fire service community should document its successes and failures to assist the fire prevention community in learning what works and what does not work. Second, inspection professionals should visit a multiple use facility during an actual event to evaluate and assess safety hazards and identify special concerns.

To learn more about the workshops, and the conclusions and recommendations, the report, ***Emerging Fire Code Issues Roundtable Report, Nashvile, TN and Bellevue, WA,*** may be downloaded. For additional information, please go to the IAFC web site: www.iafc.org.

Delivery Densities of Compressed Air Foam Studied

What are the best compressed air foam (CAF) delivery densities? This important question recently was addressed by George Crampton, National Research Council of Canada (NRCC), in his report, ***The Determination of a Safety Factor for the Application Density of Compressed-Air Foam on Flammable Liquid Fires***. CAF is accepted as and has been proven to be an effective fire suppression material for Class A and for Class B fires.

In his report, George describes a series of five full-scale Class B fire tests designed to compare low- and high-water flow conditions with the normal CAF design flow conditions and a standard foam water suppression system at the full delivered density of 6.5 l/min/m^2. The Foam Equipment and Liquid Concentrates Standard (UL162) is used for the fire condition, suppression grid spacing and the method for determining burn-back protection. Burn-back time and extinguishing performance from these adverse condition tests must meet the criteria stated in the standard and must compare favorably with the performance of a standard foam water suppression system at its full delivered density. Foam-water sprinkler systems are designed with a safety factor of 1.6 when used to protect against flammable liquid fires. Compressed air foam systems offer an alternative to foam-water sprinkler systems. The tests conducted at NRCC indicate when CAF is used at the normal design density of 1.63 l/min/m2, that compressed air foam appears to offer a safety factor that is greater than 1.6. However, the reduced flow compressed air foam provided only 10 min of burn-back protection while the normal flow CAF provided 30 min of burn-back protection. To learn more about the test procedures and results go to Research Report 180 at http://irc.nrc-cnrc.gc.ca/fulltext/rr180/ . If additional information is needed, contact George Crampton, George.Crampton @nrc-cnrc.gr.ca.

Test 1 (CAF/67 1/min)

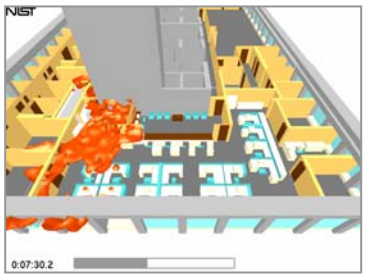
Simulating the Cook County Administration Building Fire

In order to provide insight into the fire growth and smoke movement in a tragic high rise office building fire that resulted in six fatalities and numerous injuries, NIST was asked to simulate the Cook County Administration Building fire using the Fire Dynamic Simulator (FDS) and Smokeview visualizations. The NIST team also documented the fire damage in order to compare fire model predictions with the observed physical damage. Undamaged interior finish materials and furnishings from the fire floor were obtained for use in laboratory scale heat release rate experiments. The heat release data was necessary for the fire model input and allowed better evaluation with the results from the fire model.

The Governor of Illinois asked NIST to provide technical assistance to the Governor's Review Team headed by James Lee Witt. The NIST team, headed by Daniel Madrzykowski, visited the fire scene to collect data for the model including building dimensions, floor plan, door and window locations, materials of construction and furnishings, and fuels. In addition, the Governor of Illinois' team on fire service operations and building systems helped to develop the fire timeline.

The FDS simulation provided insight into the fire development. One simulation examined the impact of automatic fire suppression sprinklers. The results suggested that had automatic sprinklers been present in the storage room where the fire is believed to have originated, they would have controlled the fire and limited the fire spread to the room of fire origin. Other simulations examined the impact of the spread of smoke into the southeast stairway with and without a functioning smoke exhaust shaft.

To learn more about the experiments and the simulations, see NIST Special Publication SP-1021, ***Cook County Administration Fire, 69 West Washington, Chicago, Illinois, October 17, 2003: Heat Release Rate Experiments and FDS Simulations***, by Daniel Madrzykowski and William D. Walton. For more information, contact Dan Madrzykowski, daniel.madrzykowski@nist.gov.



Computer animation showing flame iso-surface in office suite at 7 min 30 s after flaming ignition.

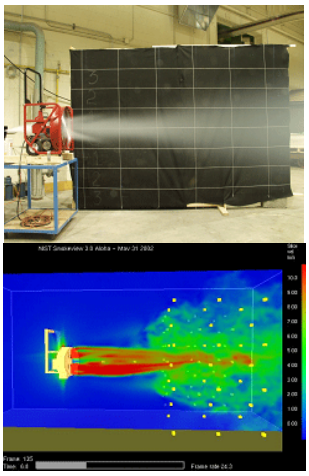
Positive Pressure Ventilation Incorporated into Fire Model

Of the three types of forced ventilation (hydraulic, negative pressure, positive pressure), it is felt that positive pressure ventilation (PPV) is the most effective as it moves air from the outside of a structure to the inside. Firefighters may open or break windows and/or doors or create vent openings as needed to increase the effectiveness of PPV.

To better understand the gas velocities that occur during a fire, Stephen Kerber at NIST has run two full scale room fire experiments to characterize the Positive Pressure Ventilation (PPV) fan in an open atmosphere and a simple room geometry. The data for the experiments are compared with simulations completed with a computational fluid dynamic model, the Fire Dynamic Simulator (FDS), and there was favorable agreement. With the correct geometry, vent placement and boundary location, FDS predicted velocities that were within 10 percent for the open atmosphere and 20 percent for the simple room geometry test. Future experiments are needed to examine the flow in other structures such as multi-floor or those of more complex geometries.

A recent report, ***Characterizing Positive Pressure Ventilation Using Computational Fluid Dynamics*** by Stephen Kerber and William D. Walton, NISTIR 7065, describes the fire tests and comparison with FDS.

For additional information, you may contact Stephen at stephen.kerber@nist.gov.



Comparison between Experimental and FDS PPV flows.

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